CITY OF CAMBRIDGE

Analysis of Curbside and Drop-Off Recycling Programs

APRIL 2004

DSM ENVIRONMENTAL SERVICES, INC.

Over 4 days, 10,280 lbs of trash and recycling was collected from about 300 households and sorted to find out how much recyclable material is still in the trash.

Most notably, an estimated 1000-1500 tons of paper (such as paperboard and cardboard) could still be recycled and diverted from the trash each year.

48% of all waste could be recycled in the existing curbside recycling program.

SUMMARY OF FINDINGS

Introduction

DSM Environmental Services, Inc. (DSM) was contracted by the City of Cambridge in October, 2003 to *identify strategies to employ to meet the City's recycling goals given*:

- *The composition of the waste stream;*
- *Current recovery/capture rates; and,*
- *The City's current financial and operational resources.*

This report presents the results of DSM's capture rate analysis of the City's curbside recycling collection program, and the results of DSM's analysis of the drop-off program.

Curbside Recycling Program Findings

DSM's findings regarding the curbside recycling program are summarized below, followed by a detailed description of the analysis that was undertaken. The findings are based on four days of sampling and sorting of waste and recyclables from four separate collection routes chosen to be representative of the City as a whole. Characteristics of the sampled routes were:

- Tuesday route (December 16) - High income, single family and two family owner occupied households
- Wednesday route (December 17) - Tenant occupied large apartment buildings ranging from 14 to 48 units.
- Thursday route (November 20) - Two to six family tenant occupied households (lower income)
- Friday route (November 21) - Two to six family tenant and owner occupied households (middle income)

Annualized results of the four days of sampling are summarized in Summary Table 1, below.

Summary Table 1.
Comparison Of Annualized Household Set-Outs and Recycling Rates

Day	Recycling (lbs)	Refuse (lbs)	Total (lbs)	Recycling Rate (%)	Recovery Rate (%)
Tuesday	1,367	1,791	3,158	43%	74%
Wednesday	320	570	890	36%	64%
Thursday	273	1,576	1,848	15%	38%
Friday	449	1,430	1,879	24%	69%

- As illustrated by Summary Table 1, the Tuesday route has the highest recycling rate (43%), with Thursday having the lowest recycling rate (15%).

- However, Summary Table 1 also illustrates that Tuesday households *generate* significantly more refuse and recyclables than households on the other routes. As a

consequence, even with the highest recycling rate, Tuesday households still set out the greatest amount of refuse.

- Because of the wide range in the amount of material generated by different households, a better measurement of recycling performance is the *recovery rate*, which measures the percent of potentially available recyclables households actually set-out for recycling as opposed to throw away in the refuse. Recovery rates of 70% or greater can be considered high recovery rates. When measured this way the Tuesday route has a high recovery rate (74%), and the Wednesday and Friday routes also have relatively high recovery rates (64 and 69% respectively). Only the sampled Thursday route has a low recovery rate (38%).

- Despite the high recovery rate for the Tuesday route, Tuesday households are still leaving the greatest quantity of recycling in the refuse, at 490 (rounded) pounds per year. The Thursday route, with the lowest recycling and recovery rate leaves the second largest quantity of recyclables in the refuse at 440 (rounded) pounds per year. The Wednesday and Friday households leave less than one-half the amount of recyclables in the refuse, at 180 and 200 pounds per year respectively.

- Therefore, Cambridge should be focusing on both high and low income households to achieve higher recycling rates.

- Based on maximum achievable recovery rates DSM has observed for recyclable materials throughout the United States, DSM believes that Cambridge could divert an additional 1000 – 1500 tons of recyclables per year by concentrating on increased recovery of paper from high and low income households in Cambridge. Given a projected tipping fee of $90/ton next fiscal year, this would result in a savings of between $90,000 and $135,000 in avoided tipping fees only, irrespective of any savings in collection costs or any additional revenues from the paper.

- The City's high recycling rate is primarily the result of high generation and recovery of newspaper. Further increases in recycling are likely to come from concentrating on corrugated recycling (especially on the Tuesday and Thursday routes), mixed paper and magazines, and chipboard recycling across all routes.

- Cambridge has already undertaken an evaluation of the most effective outreach methods to get non-participating households to participate in recycling. However, based on current set-out rates observed during this capture rate analysis, between 65 and 95 percent of households in Cambridge already recycle. Because these recycling households already are making a commitment to recycling, it is likely that concentrating on getting existing recycling households to recycle more may be more productive than concentrating on non-recyclers. This is especially the case given the potential gains in high income, owner occupied households represented by the Tuesday sampling data.

- One method that has worked in other communities to increase the quantity of material set-out by participating households is to increase the capacity of the recycling containers available to residents. In Cambridge this could be done by purchasing and distributing larger bins and/or increasing the number of free or subsidized bins available to each household.

Drop-Off Recycling Program Findings

- The capture rate analysis showed that materials accepted exclusively at the drop-off made up only 4 percent, by weight, of all material set-out in household recycling and refuse combined. In contrast, materials accepted in the curbside program made up an estimated 48% by weight of all material set out. For this reason, concentration on improving the curbside collection program is likely to lead to the biggest gains in diversion and efficiency.

- Eighty percent (rounded) of the material collected at the drop-off center is comprised of materials already collected in the curbside program. Approximately 50 percent of this material is being delivered by small businesses, who can use the Center at no cost. While the drop-off program benefits these business users, these businesses are also eligible to sign up for curbside collection of these materials if they pay for the service. Households who receive free weekly curbside collection are dropping off the remaining 50 percent of this material.

- The largest tonnage of non-curbside material collected at the drop-off is plastic film and other plastics, representing 12 percent of the total drop-off tonnage.

- Average costs for operation of the drop-off and transport of the collected materials are approximately $300/ton. By comparison, per ton costs for the curbside program are around $100.[1] For this reason, the drop-off program must be viewed primarily as a service for small businesses, and as a convenience for households already having access to the curbside collection program.

- To reduce costs, Cambridge should consider charging small business users a nominal fee (e.g., $100 per year) to use the drop-off.

- To fully realize the educational benefits of the drop-off center Cambridge should consider up grading the appearance of the drop-off and the availability of educational materials available at the drop-off center.

[1] The annual Russell contract cost excluding leaf and yard waste costs and including administrative and overhead costs net of revenues from sale of recycled materials divided by an estimated 8700 tons.

FINAL REPORT

ANALYSIS OF CURBSIDE AND DROP-OFF RECYCLING PROGRAMS
CITY OF CAMBRIDGE
April 2004

INTRODUCTION

The City of Cambridge contracted with DSM Environmental Services, Inc. (DSM) to carry out a modified capture rate study to help Cambridge better understand the effectiveness of existing recycling and waste reduction programs. The goals of the study were to:

- Identify strategies to meet City recycling goals -- 43-53% recycling and 24-34% source reduction by 2010 -- given:
    - Composition of the municipal solid waste stream;
    - Current recovery and capture rates; and,
    - Current financial and operational resources.

- Identify potential bidding options for curbside recycling, recycling processing and transfer station contracts expiring in July 2005

DSM Environmental Services, Inc. (DSM) worked with the Cambridge Department of Public Works (DPW) to complete four days of sampling and sorting of residential refuse and recyclables set out for collection during November and December of 2003. DSM used data from these capture rate studies, together with a review of the drop-off recycling program to evaluate the potential for the City to meet its recycling and waste reduction goals. This report describes the analysis undertaken and the conclusions reached by DSM.

A separate report will be issued to the Department of Public Works to address bidding options for the collection and disposal contracts expiring in July 2005.

CAPTURE RATE ANALYSIS

The purpose of a capture rate analysis is to determine what percent of recyclables that could be set out for recycling are being set out as recyclables as opposed to set out in the refuse. Based on ten years of capture rate analyses, DSM has determined that even a small number of capture rate samples, if collected randomly during “average” waste generation times, can provide relatively accurate data on the annualized behavior of households on a given route.

Given the budget for the Cambridge analysis, DSM recommended that refuse and recyclables be collected from randomly selected buildings on four routes chosen to represent different characteristics of Cambridge households. Except for the Wednesday large apartment sample, routes of at least 400 households were selected for sampling based on census data and discussions with DPW and Russell (recycling collection contractor) to identify areas representative of the route day and in particular the characteristics listed below. Routes selected for sampling were:

- Tuesday route (December 16) - High income, single family and two family owner occupied households
- Wednesday route (December 17) - Tenant occupied large apartment buildings ranging from 14 to 48 units.
- Thursday route (November 20) - Two to six family tenant occupied households (lower income)
- Friday route (November 21) - Two to six family tenant and owner occupied households (middle income).

Sample sizes varied between a low of 54 and a high of 135 households. While DSM does not represent that these samples are statistically valid samples, based on previous sampling DSM is confident that samples of at least 50 households (in relatively homogenous routes) are representative of household behavior on the sampled route.

Sampling and Sorting Protocol

DSM met with DPW staff and a Russell representative the day before the two sampling events to map out an area of each route day that everyone thought was representative of the type of housing that DSM had identified as important to sample.

On the day of sample collection, DPW and Russell collection vehicles were directed to stay out of the area selected for sampling until after the sample was collected. Two DPW packer trucks were then used to collect the sample near the beginning of the collection day.

On three of the four days of sampling DSM rode in the trucks and selected every 6th set-out on the route selected for sampling whether it was refuse and recycling, just refuse or just recycling. Collecting from every 6th set-out irrespective of what was set out eliminates bias in sample selection, and assured that a minimum of 50 set-outs could be collected on a 400 stop route. In all cases, DSM took all of the refuse and recycling set out at that stop. If the stop represented more than one household, DSM collected from all the refuse bins and all the recycling containers set out and also counted the number of mailboxes in the building to determine how many households were represented by the set-out.

The fourth day of sampling was dedicated to large apartment buildings. In this case the samples were selected from a list of buildings prepared by the Recycling Division to represent lower income, more transient population households. A list of approximately 16 buildings was initially developed by the Recycling Division, and then narrowed to 12 buildings based on discussions of the characteristics of the households in the building. A route map was then prepared to efficiently drive around to collect the sample. All of the refuse and recyclables from each building on the sample list was collected until refuse and recyclables from 135 households (based on unit counts in the buildings) had been collected and DSM determined that the sample size was as large as could practically be sorted during the remainder of the day.

For all samples, refuse was put in one packer truck and the recycling (and leaf and yard waste on two sample days) in a second packer truck.

In all cases, any material that would normally be collected as refuse was collected as part of the refuse sample. This included bulky wastes, small quantities of C&D wastes, and cardboard that had not been broken down to meet the recycling specifications. Special pick-ups for materials such as CRTs, appliances and other special wastes were not collected. However, only one of

the sampled households over the four days of sampling set out a special waste - one CRT monitor - on the Friday route.

Similarly, the recycling sample included everything that had been set out for recycling to ascertain how much contamination households were setting out for recycling.

After sample collection both the refuse and recycling truck drove to the KTI facility and weighed their loads before dumping at a designated area on the tipping floor. Each truck went over the scale again after dumping the sample so that a true net weight of the sample could be obtained.

The Project Team, which included DSM, DPW staff, and volunteers from the City's Recycling Advisory Committee then sorted the recyclables set-out for recycling by material category and weighed each material to determine the composition and weight of all materials set-out for recycling. Materials not accepted in the program (including refuse) were also sorted out and weighed to determine the contamination rate of the sample load.

Next the refuse sample was sorted. Material was sorted into 25 categories, which represented all curbside and drop-off recyclable categories, plus household hazardous waste (HHW), construction and demolition (C&D) materials, and electronics. All other material not fitting one of the 25 categories was negatively sorted into a trash container.[2] Weights were then obtained for all the sorted materials. These weights were subtracted from the net of the total sample obtained from the full and empty truck weights, to determine the weight of the remaining refuse.

Results

To help with interpretation of the results, the following terms are defined:

Set-out Rate: The percentage of households setting out refuse or recycling bins on the day of sampling. *Set-out* rates are different from *participation* rates because a *participation* rate is usually measured over a 4 to 6 week period. Not every household who *participates* in recycling will *set out* refuse or recycling on every collection day.

Recovery Rate: The percentage, by weight, of each recyclable material (or total recyclable material) set out for recycling versus set out in the refuse. The *recovery rate* is calculated by dividing the weight of the recyclable material set out for recycling by the total weight of that same material set out for recycling and set out in the refuse. It should be noted here that although DSM often refers to the sampling and sorting carried out in Cambridge as a "*capture rate*" analysis, a true *capture rate* analysis would sample from only those households setting out both recycling and refuse – that is the sample would represent only *participating* households – and would be looking at what percent of recyclables these *participating* households left in the refuse versus set out for recycling. By contrast, a *recovery rate* looks at the amount of recyclables set out by participating *and* non-participating households.

[2] In a *negative sort*, the material is not sorted out from the rest of the waste stream and instead left behind in one category, in this case categorized as *all other waste*. To *positively sort* means that a specific material(s) is sorted out from the rest of the waste in a sample.

Recycling Rate: The percentage, by weight, of material recycled calculated by dividing the weight of recyclable material set out for recycling by the total weight of recycling and the refuse. Note that for this study a *recycling rate* is only calculated for the curbside program. Recycling rates were not calculated for the drop-off and leaf and yard waste programs.

Contamination Rate: The percentage, by weight, of non-recyclable material set out in recycling bins/containers versus the total weight of the material set out for recycling.

Table 1 summarizes the results of the four days of sampling. Each of the relevant measurements is discussed in more detail below.

Table 1.
Summary of Data Analysis - Recycling Program Measurements

Route Day	*Set-out Rate* (%)	*Recycling Rate* (%)	***Recovery Rate*** **(%)**	*Contamination Rate* (%)	*Leaf & Yard Waste Recovery Rate* (%)
Tuesday	85%	43%	**74%**	3%	NA
Wednesday	NA	36%	**64%**	2%	NA
Thursday	42%	16%	**38%**	3%	24%
Friday	46%	24%	**69%**	5%	80%

Recycling Set-out Rate

As illustrated in column one of Table 1, 85 percent of the sampled households on the Tuesday route set out recyclables on the day of sampling. This was almost double the recycling set-out rate for the Thursday and Friday routes. As discussed above, recycling set-outs on a single day are not the same as recycling participation rates. However, as one would expect, high set-out rates typically represent high participation rates.

Based on data developed by DSM in the Cedar Rapids, Iowa metropolitan area (similar to data Clear View Consulting has developed in Massachusetts) a weekly set-out rate of 85 percent is likely to represent about a 95 percent monthly participation rate. Weekly set-out rates of 42 and 46 percent are likely to represent monthly participation rates of around 65 percent.

It was not possible to obtain a recycling set-out rate for the Wednesday, large apartment route, because households share toters to participate in the recycling program, and place all refuse together on collection day.

Recycling Rate

Column two of Table 1 presents the calculated recycling rates for the four sampled routes. As one would expect from the high set-out rates, Tuesday households also have a high recycling rate when compared to the other three sample areas. However, it is important to note that one of the reasons that the Tuesday households have such a high recycling rate is that they *generate* a lot of recyclables, and a lot of refuse. As illustrated in Table 2, Tuesday households generate 3.5 times as much total refuse and recyclables as the sampled Wednesday households.

Table 2 was created by taking the total weight of the sample of material set out for recycling and set out as refuse, divided by the number of households sampled, and then multiplied by 52 weeks to create an annualized set-out.

Table 2.
Comparison Of Annualized Household Set-Outs

Day	Recycling (lbs)	Refuse (lbs)	Total (lbs)
Tuesday	1,367	1,791	3,158
Wednesday	320	570	890
Thursday	273	1,576	1,848
Friday	449	1,430	1,879

Recovery Rates

Because of the wide range in the amount of material generated by different households, a better measurement of recycling performance is the recovery rate, which measures what percent of potentially available recyclables households in each of the four sampled routes are actually recycling.

Based on data from other municipalities that DSM has analyzed, recovery rates of 70 percent or greater can be considered high recovery rates. When measured this way (column three of Table 1), the Tuesday route has a high recovery rate (74%), and the Wednesday and Friday routes also have relatively high recovery rates (64 – 69% respectively). Only the sampled Thursday route has a low recovery rate (38%).

Therefore, even though Friday's *recycling rate* is 19 percentage points less than Tuesdays, the *recovery rate* for Friday is only 5 percentage points less than Tuesdays, which means that the Friday households are doing almost as good a job as the Tuesday households at setting out recyclables for recycling.

Maximum Achievable Recycling Rates

Tuesday households set out almost two times as much refuse and recyclables as Thursday and Friday households, and 3.5 times as much refuse and recyclables as Wednesday households. Therefore, even though the Tuesday households have a high recycling and recovery rate, they could still be leaving a significant amount of recyclables in their refuse. Table 3, below presents

estimated annual quantities of recyclables per household left in the refuse for each of the sampled routes.

Table 3.
Annualized Pounds/Household, Recyclables in Refuse

Day	Recyclables		Refuse	Total	Current	Maximum
	In Recycling Bin	In Refuse		Recycling & Refuse	**Recycling Rate**	**Achievable Recycling Rate**
	(lbs)	(lbs)	(lbs)	(lbs)	(%)	(%)
Tuesday	1,367	489	1,302	3,158	43%	59%
Wednesday	320	180	390	890	36%	56%
Thursday	273	442	1,133	1,848	15%	39%
Friday	449	201	1,229	1,879	24%	35%

Recovery Rate By Material

Table A.1 and A.2 attached to the end of this report present the recovery rate data from the four days of sorting, by material. Recovery rates by material are calculated in Table A.1. Table A.2 converts the per-household sampling data to annualized per-household pounds by material. This material-by-material analysis can be useful in defining what materials Cambridge should go after in the neighborhoods identified above. A review of Tables A.1 and A.2 indicate:

- The high recovery rates for the Tuesday and Friday routes are primarily the result of high recovery rates for newspaper (ONP), and to a lesser extent, glass – both heavy materials.

- By weight, paper represented from a low of 67% to a high of 81% of recyclables set out each day. More importantly newspaper represented 45% of total material set out for recycling in Cambridge, even though it only represented 34% of total recyclables (in refuse and recyclables), indicating the importance of newspaper to overall recovery rates in Cambridge.

- Newspaper also represents between 6% and 27% of *total* material in the waste stream (including recycling and refuse), which translates into an estimated per household annual generation rate of newspaper ranging from a low of 140 pounds (Thursday routes) to a high of 890 pounds (Tuesday route). Thus, newspaper has a significant impact on total recycling rates in Cambridge.

- There is room for improvement with respect to corrugated recycling (especially on the Tuesday and Thursday routes), mixed paper and magazines, and chipboard recycling across all routes.

- There is also room for improvement with respect to plastic bottles and containers, although, because they are light, the impact on avoided costs associated with increasing recovery of these materials will be significantly less.

- If the City is looking not only for avoided tipping fee savings but also reductions in collection costs associated with eliminating one or more refuse trucks through the diversion of additional recyclables, then the impact of removing additional plastic bottles becomes more important.

Quantifying Potential Increases In Recovery

Data gathered by income and household type over the four days of sampling can be used, together with household income data to estimate how much more material might be recovered curbside from households if Cambridge were to achieve high recovery rates for additional materials, especially corrugated containers, chipboard and mixed paper/magazines.

Recovery rates by material presented in Table A.1 can be compared against recovery rates that DSM has measured in other municipalities. Table 4 compares recovery rates measured by DSM in Cambridge with high recovery rates DSM has measured in other areas of the United States. Different high rates are used for three income categories. In most cases this does not reflect differences due to income per se, but more likely to the more transient nature of lower income households.

No comparisons have been made for recyclable bottles and cans because the measured recovery rates in Cambridge for bottles and cans can be considered high already. The only container with a low recovery rate is injection molded plastic containers (non-bottle plastic). However, given that KTI routinely disposes of these containers (due to a lack of markets for mixed grades of plastics) and this material represents a fairly low amount of tonnage, they have not been considered.

Table 4.
Comparison of Current and Potential Recovery By Household Income

Material	High Income			Medium Income			Low Income		
	Current	Potential	Change	Current	Potential	Change	Current	Potential	Change
OCC	53%	85%	32%	73%	75%	2%	27%	60%	33%
Mixed Paper	56%	65%	9%	56%	60%	4%	29%	50%	21%
Chipboard	29%	65%	36%	42%	60%	18%	32%	55%	23%
Newspaper	91%	90%	0%	89%	90%	1%	56%	75%	19%

The realistic high recovery rates by income and by material in Table 4 can then be applied against annualized pounds per household by income level for these designated materials (Table A.2) in Cambridge to estimate the potential for increasing recycling in Cambridge.

The results, presented in Table 5 illustrate the increase in pounds per household per year recovered that DSM believes may be possible to achieve for different households in Cambridge.

Table 5.
Potential Increase in Lbs/HH/Yr, By Income

Material	High	Medium	Low
	(lbs)	(lbs)	(lbs)
OCC	41	1	57
Mixed Paper	36	7	40
Chipboard	44	9	12
Newspaper	0	3	20
Total	121	20	130

Applying the potential increase in pounds per household to the number of households by income level based on the 2000 census, illustrates that simply concentrating on increasing recovery rates for paper, especially from high and low income households can yield roughly 1400 (rounded) additional tons per year.

It should be noted here that the household count used in Table 6 is taken from the 2000 census, *Cambridge Income Information by Census Tract: 1999* and only includes "family households". Thus the total only represents 42,615 of the total of 45,297 households DPW reports serving. Given that the Wednesday sort of large apartment units, which were assumed to house primarily students and other residents classified as "non-family", yielded low levels of potentially available recyclables, the estimates in Table 6 probably more realistically represent what could be achieved by increasing recovery levels of the specified materials.

The division of households into the three income categories was also somewhat arbitrary. DSM used the median income data and assumed that all households with incomes greater than 110 percent of median income would be considered high-income households, and all households with income less than 87% of median income would be considered low-income households.

Table 6.
Estimated Increase In Annual Recovery By Income Level

Income	Households	Lbs/HH/Yr	Tons/Yr
	(#)	(lbs)	(tons)
High	12,422	121	752
Medium	23,546	20	235
Low	6,647	130	432
Total	42,615	NA	1419

The estimates presented in Table 6 are based on one day of sampling per income level, which is a small sample size. When combined with DSM's assumptions about the income levels that households fall into, it is realistic to assume that the accuracy of these estimates fall within a range of –30% to +10%, which would mean that Cambridge could expect to achieve increased recovery ranging from 1000 tons to 1500 tons of additional material through changes in the recycling program. Given a projected tipping fee of $90/ton next fiscal year, this would result in a

savings of between $90,000 and $135,000 in avoided tipping fees only, irrespective of any savings in collection cost savings.

Cambridge has already undertaken an evaluation of the most effective outreach methods to get non-participating households to participate in recycling (*Community-Based Recycling Outreach Participation Project*). However, based on current set-out rates observed during this capture rate analysis, between 65 and 95 percent of households in Cambridge already recycle. Because these recycling households already are making a commitment to recycling, it is likely that concentrating on getting existing recycling households to recycle more may be more productive than concentrating on non-recyclers. This is especially the case given the potential gains in high income, owner occupied households represented by the Tuesday sampling data. These households are typically not transient, making it much easier to present and reinforce consistent messages about what materials can be recycled, and the importance of recycling to avoided cost savings for Cambridge.

In any case, the recovery rate data presented in this report represents some combination of participating and non-participating households. Therefore, different messages targeting participating and non-participating households, when combined might achieve the increases projected in Table 6. Just as importantly, Cambridge may want to survey residents to ascertain why they are not placing all their material out for recycling. It has been DSM's observation that high generating households appear to set out greater quantities of recyclables if they have sufficient bin storage capacity. The standard 18-gallon set-out bins used by Cambridge were adequately sized when they were first introduced. However, quantities of recyclables have increased significantly since then. It may be that achieving the increased tonnage projected in Table 6 will require a combination of targeted education and promotion (especially for lower income households), and changes to the collection system to provide more storage for recyclables for the higher income households. Given that Cambridge already uses toters for larger apartment building recycling, it may make be worthwhile considering providing toters to single-family households as a means of increasing recovery rates of material.

Final Observations

The curbside program has the potential to collect 48 percent of all of the refuse collected by the City of Cambridge, while the drop-off program represents only 4 percent of the material collected by Cambridge. Therefore, it is likely that maximizing diversion and avoided cost savings will be achieved primarily by focusing on the increased efficiency of the curbside collection program, and/or collection of new materials such as mattresses and other bulky items.

DROP-OFF RECYCLING PROGRAM

While the primary goal of the capture rate analysis was to evaluate the effectiveness of the curbside collection program, materials accepted at the Cambridge drop-off were also sorted from the refuse. The capture rate analysis showed that materials accepted at the drop-off (excluding cardboard which is also accepted in the curbside program) made up only 4 percent, by weight, of all material set-out in household recycling and the refuse combined. In contrast, materials accepted in the curbside program made up 48% by weight of all material set out. For this reason, as previously discussed with Cambridge, concentration on improving the curbside collection program is likely to lead to the biggest gains in diversion and efficiency.

However, as part of DSM's review of Cambridge's recycling program, DSM was asked to make recommendations on ways to improve the drop-off program. DSM's scope of work specified that DSM should address:

- Should materials be added to the drop-off or the curbside program?
- Should changes be made to the drop-off operation?

In addition, Cambridge is interested in reducing overall Recycling Division costs and asked DSM to evaluate whether cost savings might be achieved in making changes to the drop-off program.

History and Use of Drop-off

Cambridge's drop off recycling center is located at 147 Hampshire Street behind the Public Works Garage and is open Tuesday and Thursday afternoons (4 – 7:30pm) and Saturday from 9-4pm. The center has been operating since 1989, and serves both households and small businesses. The City restricts use to Cambridge residents only and small businesses and non-profit organizations in Cambridge with 50 employees or less.

The City conducted surveys on drop-off center use in 1998 and in 1995. While the number of City residents and businesses using the drop-off center were not estimated, the City found that between 11 and 16 percent of users surveyed were non-residents. These surveys also found that between 21 and 23 percent of users were businesses. However the Recycling Program Manager reports that businesses deliver over half of the material dropped off. (No weigh data are available on business quantities.)

Materials Accepted and Annual Quantities

The types of materials accepted for recycling (or reuse) at the drop-off center are described in Table 1 below. Annual quantities collected from the drop off are also estimated in Table 1. These estimates are based on fiscal year 2003 data, adjusted for increases seen in the first six months of FY 2004.

As illustrated by Table 1, 80 percent (rounded) of the material collected at the drop-off center is comprised of materials that are already collected in the curbside program. As stated above, approximately 50 percent of this material is being delivered by small businesses. While this

drop-off program obviously is benefiting these business users, these businesses are eligible to sign up for curbside collection of these materials with private haulers if they pay for the service.

Households who receive free weekly curbside collection are dropping off the remaining 50 percent of this material. This is consistent with behavior that DSM recently observed in a similar study in the Cedar Rapids, Iowa metropolitan area. Focus groups found that households used drop-offs even though they had weekly curbside collection service because they found the instructions of what they could and could not recycle easier at the drop-off and because they had more flexibility with the time they could use the drop-off over a single day per week that they could set out material.

The largest tonnage of non-curbside material collected at the drop-off is plastic film and other plastics, representing another 12 percent of the total drop-off tonnage. Many residents who classify themselves as "environmentalists" are interested in finding a way to recycle the plastic that they generate, and the drop-off fulfills this need. However, it is interesting to note that in the past many grocery chains accepted plastic film for recycling at no charge to the customer. This function is now being performed by the City though the drop-off.

Table 7.
Materials Accepted at the Drop-Off and Annual Quantities Delivered

	Material	Description	Quantities (FY 04 tons)
Drop-off Recycling (Residents & Businesses)	**Books**	Hardcover and soft cover books	small quantity, reuse
	Cardboard	Old corrugated cardboard	56.57
	Mixed paper	All paper except tissue papers	88.67
	White paper	White office paper	9
	Cans & bottles	Plastic, glass and bi-metal bottles and cans	17
	Plastic bags and film	Plastic film grocery and retail bags and all film plastic packaging free of contamination	26.04
	Rigid plastic containers	Unmarked rigid containers and nursery pots	Included above
	Styrofoam	Polystyrene food service containers, peanuts and EPS packaging	Included above
	Textiles	Clothing	Reuse
	Electronic media	CDs, floppy disks and VHS tapes	Small quantity
Drop-off HHW	**Batteries**	Non-Alkaline - NiMH, NiCD, Hg, Li Ion, Pb Acid, AgO2	1.1
	Fluorescent bulbs	Tubes or other florescent bulbs that can be easily identified	NA
	Mercury containers devices	Thermometers, thermostats, and other easily identified mercury container devices.	NA
	Motor Oil	In containers, not in filters	6
		Total TPY:	**204**

In addition, miscellaneous non-CRT electronics are accepted at Drop-Off, although exact weights are not known because they are commingled with CRTs.

Annual costs associated with operating the drop-off are outlined in Table 2 below. Labor costs are the highest cost item (52 percent), followed by hauling and processing costs. As Table 2 illustrates, when labor costs are spread over the relatively small quantity of material accepted at the drop off, average costs per ton are approximately $300. When transport and processing costs are allocated by material, the highest cost item to manage is plastics (approximately $590 per ton) while the lowest cost item is paper (approximately $53 per ton).

However, this type of material-by-material allocation would illustrate similar discrepancies in the curbside collection program, with allocated costs for lightweight plastics significantly higher than for heavier weight paper. For example, curbside collection cost allocations completed for the American Plastics Council in 1995 based on twelve model cities programs throughout the United States indicated that lightweight plastic and aluminum containers cost ten times as much on a per ton basis as heavier weight paper, glass and steel cans[3].

In contrast to the curbside program however, the total cost of operating the drop-off center is relatively small ($1.2 million for the curbside contract alone as compared to approximately $65,000 for the drop-off). And, if drop-off costs are spread over all households in Cambridge, drop-off program costs are relatively low at approximately $1.50 per household per year (as opposed to approximately $16.00 per household per year for the cost of the curbside recycling collection service and $6.00 per household per year for the leaf and yard waste collection).

[3] *How To Collect Plastics For Recycling, Lessons from the Model Cities Demonstration Program,* American Plastics Council, 1995

Table 8.
Annual Costs of Drop-off Recycling Center Operation

		FY '04	Quantities Collected			Cost per ton
Labor		*($)*	*tpy*	*other*	*Units*	*($)*
Drop-off Monitor (1)		$18,096				
Benefits		$11,130				
Subtotal:		**$29,226**				
Hauling and Processing Costs	*$ per unit*					
Hauling (OCC, Paper, Commingled)	$127	$9,156	171.24			**$53**
Hauling/Processing (PS, bags, containers)		$15,280	26.04			**$587**
Recycling Fee (Fluorescent bulbs and mercury)	$0.68	$2,790	NA	4103	Bulbs	**$340**
Recycling Fee (Batteries, floppies, CD's)	NA	$1,100	1.1			**$1,000**
Waste Oil	$0	$0	6	1500	gallons	**$0**
Subtotal:		**$28,326**	**204**			**$139**
Capital and Other Operating Costs	*Total Cost*					
Equipment (Roll-offs, stairs, signs)	$18,000	$1,976				
Materials and Supplies		$500				
Subtotal:		**$2,476**				
Total:		**$60,029**	**204**			**$294**

(1) Labor costs shown above are based on the Monitor spending one full day (7.5 hours) per week on public area recycling. Benefits are allocated to the drop-off based on this percentage of time as well.

Findings

Should materials be added to the drop-off or the curbside program?

Based on the capture rate sorting completed in November and December, there is no single material not currently accepted in the curbside or drop-off program that should be added to the drop-off program. Instead, as previously presented by DSM, a renewed focus on increasing the capture rate of curbside materials should be the first step toward increasing diversion and reducing collection and disposal costs (e.g. corrugated recycling, mixed paper and magazines, chipboard recycling). In addition, while there is room for improvement with respect to increasing plastic bottles and containers recycling, because they are light, the impact on avoided costs associated with increasing recovery of these materials will be significantly less.

Only a program that concentrated on food waste would provide significant additional diversion potential. However, separate food waste collection, either at the curbside or the drop-off would require significant analysis before any plans to move forward are implemented. This is because of the potential health and odor issues associated with food waste collection, in addition to the need for food waste processing capacity, either in Cambridge or within a reasonable hauling distance of Cambridge.

Other materials left in the waste stream that might be added to the Drop-Off include C&D wastes. Small appliances have already been added to the CRT collection contract. However both C&D wastes and small appliances were found in very small quantities during the capture rate analysis. In addition, C&D wastes are not homogenous enough to offer immediate or obvious reuse or recycling opportunities.

However, based on the bulky waste set-out information provided by the drivers to DSM, and DSM's limited observations of material set-out on the street (January 9, 2004), mattresses do represent one of the largest single categories of material collected for disposal that is not currently recycled in Cambridge.

Conigliaro Industries offers a mattress-recycling program in Framingham. According to Conigliaro's web site, hauling and processing costs for a 40 cubic yard container of mattresses will cost about $1000[4]. Given the number of mattresses that DSM estimates can fit into a 40-yard container located at the Drop-Off Center, the weight of a 40-yard container full of mattresses is likely to be less than one ton. Therefore, a mattress recycling program will only benefit Cambridge in terms of cost savings in the area of refuse collection costs. This is because of the relatively large volume and low weight of mattresses (similar to plastics).

Are cost savings possible for the drop-off program?

Clearly, plastic collection at the drop-off would be the most logical program to eliminate to reduce drop-off costs. One way to accomplish this might be to discuss with the grocery stores in Cambridge whether they could begin accepting plastic shopping bags for recycling.

Another approach to reducing plastic recycling costs at the drop-off would be to bale the material and deliver loads of mixed bales to Conigliaro (who will accept mixed loads of baled plastics). DSM is currently working with the American Plastics Council on testing of two mini-balers in New Hampshire for plastic containers. A mini-baler costs approximately $7,000 but it would allow Cambridge to ship dense loads of plastics to Conigliaro – perhaps in conjunction with a mattress collection program using a 40-yard box. This mini-baler is only 2' wide, by 8' long by 4' high, and can run off of single-phase power. It produces 20"X20"X36" bales weighing approximately 125 – 150 pounds[5]. These bales could be stored on-site until a 30-yard container could be fully loaded, significantly reducing hauling costs. The mini-baler could fit in the space alongside the ramp to Roll-off #1 where the PVC plastic stands are currently located. Alternatively a 30-yard, open top roll-off container could be purchased, at a cost of about $3,500, and could be configured with a ramp so that bales could be loaded with a forklift and stored in the container. The container could be placed where Roll-off #3 is currently located.

Should changes be made to the drop-off operation?

Given the relatively high per ton costs associated with the drop-off center, and given that 80 percent of the material handled at the drop-off can be set out for collection curbside, one option would be to close the drop-off entirely.

Alternatively, it might make more sense to simply close the drop-off for materials collected curbside, and keep the drop-off open for materials that are not collected curbside. DSM believes that maintaining the drop-off center for at least some materials, even at the high per ton costs, is

[4] Estimate based on Conigliaro's cost estimating tool on website.
[5] TSI Manufacturing Company, Inc., Phoenix, Arizona, TC-700 Recycling Baler.

a good idea because it would be very difficult if not impossible to add it back at a future date due to area real estate costs and space constraints at the public works garage. The drop-off provides *the opportunity* for the City to offer collection of three types of items:

- Recyclable materials not accepted at KTI or other MRFs (so that they can't be included in the curbside program) but that City residents demand recycling options for, such as plastic grocery bags and film, textiles, and books.

- Household hazardous wastes, including Universal Wastes that must be eliminated by regulation from the municipal solid waste stream, such as waste oil, florescent tubes mercury items, batteries, and electronics.

- Other landfill banned materials such as construction and demolition wastes.

It should be noted here that if Cambridge continues with a drop-off center for the materials listed above that are prohibited from municipal waste, the *marginal cost* of continuing to offer drop-off of paper and commingled containers is relatively low, and there are benefits to some small businesses. DSM is currently working with Cambridge on a separate project to increase business recycling. This project will provide additional data on the potential demand for the drop-off center from small businesses. One way to offset the cost of operating the drop-off might be to charge a nominal fee (e.g., $100/year) for business use of the drop-off.

Finally, the drop-off center helps foster the Recycling Division's mission[6] by providing a location to recycle some problem materials, and an opportunity for people who use the drop-off to obtain information on other Cambridge waste management programs. However, to fully realize this educational component of the drop-off requires a more attractive center with an area for distribution of educational materials. DSM realizes that this is difficult given space constraints, but believes that if Cambridge does make a decision to continue the drop-off center, that attention be paid to improving the educational potential of the drop-off for both residents and the small business community.

[6] "…to increase the sustainability of the City by educating and motivating the Cambridge community to value waste reduction and to integrate sustainable habits into daily activities. We seek to foster a culture that encourages people to consume less, reuse and donate materials, and recycle what cannot be eliminated or reused."

TABLE 1

Composition of Materials Set-Out in Recycling and Refuse

City of Cambridge Recycling Program - Pilot Routes

	Thursday Route				Friday Route				Tuesday Route				Wednesday Select Apartments				Average, total sample				
Material	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**Recovery Rate (%)**	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**Recovery Rate (%)**	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**Recovery Rate (%)**	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**Recovery Rate (%)**	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**Recovery Rate (%)**	
Curbside Materials																					
Paper																					
OCC	60.2	160.8	221.0	**27%**	53	19	72	**73%**	70.2	62	132	**53%**	90.7	68	159	**57%**	274	310	583	**47%**	**6%**
ONP (1)	78.2	60.6	138.8	**56%**	218	28	245	**89%**	807	82	889	**91%**	297	54	350	**85%**	1,400	224	1,624	**86%**	**16%**
Mixed Paper, Magazines & Paper Cartons	72.9	175.0	247.9	**29%**	98	78	176	**56%**	238	185	423	**56%**	208	172	380	**55%**	616	610	1,226	**50%**	**12%**
Chipboard	21.9	46.2	68.1	**32%**	23	32	55	**42%**	38	92	130	**29%**	19	33	51	**36%**	102	203	304	**33%**	**3%**
Subtotal:	233.2	442.6	675.8	**35%**	391.2	156.4	547.6	**71%**	1,153.6	420.5	1,574.1	**73%**	613.6	325.9	939.5	**65%**	2,392	1,345	3,737	**64%**	**36%**
Containers																					
Glass containers	75.4	47.8	123.2	**61%**	61	24	85	**72%**	187.4	46	233	**80%**	163.8	70	234	**70%**	488	187	675	**72%**	
Plastic Bottles	26.1	31.1	57.2	**46%**	19	13	32	**59%**	46	15	61	**75%**	29	27	56	**52%**	120	86	206	**58%**	
Plastic Containers (Marked)	1.6	9.9	11.5	**14%**	1	10	11	**12%**	9	12	21	**43%**	7	20	27	**27%**	19	52	71	**27%**	**1%**
Metal containers & foil	9.6	30.1	39.7	**24%**	11	14	25	**45%**	24	15	39	**61%**	16	25	41	**39%**	61	84	145	**42%**	
Subtotal:	112.7	118.9	231.6	**49%**	92.2	60.3	152.5	**60%**	266.1	87.4	353.5	**75%**	216.3	142.2	358.5	**60%**	687	409	1,096	**63%**	**11%**
Total curbside:	345.9	561.5	907.4	**38%**	483.4	216.7	700.1	**69%**	1,419.7	507.9	1,927.6	**74%**	829.9	468.1	1,298.0	**64%**	3,079	1,754	4,833	**64%**	**47%**
Contamination																					
Unmarked plastic contaienr	1.2				2.0				6.0				3.6				13				
Other materials	10.4				22.8				33				17				83				
Contamination rate	***3.3%***				***4.9%***				***2.7%***				***2.4%***				***3.0%***				
Drop-off Materials																					
Books	0.0	3.4	3.4		0	0.0	0.0		0	0.0	0.0		0	0.0	0.0		0	3	3		
Plastic bags and film	1.0	21.7	22.7		1	23.9	24.9		0	29.8	29.8		0	24	24		2	99	101		
Styrofoam (EPS & Food serv	0.7	10.9	11.6		0.2	5.8	6		0	3.3	3.3		0	4.3	4.3		1	24	25		
Plastic casings (CD cases)										0			0	1.6	1.6		0	2	2		
Unmarked plastic containers	1.2	9.8	11.0		2	8	10		6	9	15		4	14	18		13	41	54		
Textiles																					
Clothing and other textiles	0	20.6	20.6		0	9.6	9.6		0	9	9		0	13.8	14		0	53	53		
Shoes		2.0	2.0			0				2	2			14.8	14.8			19	19		
Rugs		11.0	11.0			0				0	0			8.8	8.8		0	20	20		
Electronic Media		0.6	0.6			0				2.8	2.8			1.5	1.5		0	5	5		
Batteries																					
Alkaline		0.6	0.6			0.1	0.1			0.0	0.0			0.2	0.2		0	1	1		
Non-alkaline household batteries		0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0		0	0	0		
Car batteries		0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0		0	0	0		

Mercury devices		0.0	0.0			0.2	0.2			0.0	0.0		0.1	0.1	0	0	0	
Motor oil (1)		0.1	0.1			4.0	4.0			0.0	0.0		0.0	0.0	0	4	4	
Other HHW (1)		2.6	2.6			1.2	1.2			1.2	1.2		1.0	1.0	0	6	6	
Small Appliances		23.4	23.4							1.2	1.2		19.2	19.2	0	44	44	
Tires		0.0	0.0			0.0	0.0			0.0	0.0		0.0	0.0	0	0	0	
Scrap metal		15.4	15.4			10.1	10.1			7.2	7.2		13.1	13.1	0	46	46	
Total drop-off:	**2.9**	**122.1**	**125.0**		**3.2**	**63.1**	**66.3**		**6**	**65.3**	**71.3**	**3.6**	**116.5**	**120.1**	**16**	**367**	**383**	**4%**
Yard Waste	**32.4**	105.2	137.6	**24%**	353.2	89.6	442.8	**80%**	NA	0.0	0.0	NA	0.0	0.0			580	
Residue in yard waste	**5.2**		5.2		0				0			0					5	
Other Materials																		
Construction & Demolition W	0.0	127.4	127.4		0.0	82.4	82.4		0.0	0.0	0.0	0.0	11.6	11.6	0	221	221	
Paint Cans	0.0	0.8	0.8		0.0	0.0	0.0		0.0	0.0	0.0	0.0	4.0	4.0	0	5	5	
All Other Waste		1,083.0	**1,083.0**			1,088.3	**1,088.3**			1,286.8	**1,286.8**		879.8	**879.8**		4,338	4,338	
Total Material			2,381.2				2,379.8				3,285.7			2,313.5			10,360	
Truck Weights (KTI Scales)	420.0	2,000.0	2,420.0		880	1,540.0	2,420.0		1400	1,860.0	3,260.0	700	1,480.0	2,180.0	3,400	6,880	10,280	
															33%			
Total Material Weighed	391.6	917.0	1,308.6		862.6	451.8	1,314.3		1,452.9	573.2	2,026.1	846.6	600.2	1,446.8	3,554	2,542	6,096	

(1) Friday recycling weight reduced by 25% to account for moisture in newspaper.

Annualized Pounds Per Household Set-Out

City of Cambridge Recycling Program - Pilot Routes

Sample Size	***66***			***56***			***54***			***135***		
	Thursday			**Friday**			**Tuesday**			**Wednesday Apartments**		
Material	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*	**In the Recycling** *(lbs)*	**In the Refuse** *(lbs)*	**Total** *(lbs)*
Curbside Materials												
Paper												
OCC	47.4	126.7	174.1	48.8	17.6	66.5	67.6	59.6	127.2	34.9	26.1	61.1
ONP	61.6	47.7	109.3	202.0	25.6	227.7	777.5	78.8	856.3	114.2	20.7	135.0
Mixed Paper, Magazines & Paper Cartons	57.5	137.9	195.3	91.0	72.1	163.1	228.9	178.3	407.2	80.0	66.2	146.2
Chipboard	17.3	36.4	53.7	21.4	29.9	51.3	36.9	88.2	125.1	7.2	12.5	19.7
Containers												
Glass containers	59.4	37.7	97.1	56.6	22.3	78.9	180.5	43.9	224.4	63.1	26.9	90.0
Plastic Bottles	20.6	24.5	45.1	17.4	11.9	29.3	44.2	14.4	58.6	11.2	10.5	21.7
Plastic Containers (marked)	1.3	7.8	9.1	1.2	8.9	10.1	8.7	11.5	20.1	2.8	7.7	10.6
Metal containers & foil	7.6	23.7	31.3	10.4	12.9	23.3	22.9	14.3	37.3	6.2	9.7	15.9
Subtotal, curbside recyclables:	**273**	**442**	**715**	**449**	**201**	**650**	**1,367**	**489**	**1,856**	**320**	**180**	**500**
Drop-off Materials												
Books	0.0	2.7	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plastic bags and film	0.8	17.1	17.9	0.9	22.2	23.1	0.0	28.7	28.7	27.7	9.2	36.9
Styrofoam (EPS & Food service)	0.6	8.6	9.1	0.2	5.4	5.6	0.0	3.2	3.2	3.1	1.7	4.7
Plastic casings (CD cases)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.6	0.6
Unmarked plastic containers	0.9	7.7	8.7	1.9	7.6	9.5	5.8	8.5	14.3		5.4	5.4
Textiles												
Clothing and other textiles		16.2	16.2	0.0	8.9	8.9	0.0	8.7	8.7	0.0	5.3	5.3
Shoes		1.6	1.6	0.0	0.0	0.0	0.0	1.9	1.9	0.0	5.7	5.7
Rugs		8.7	8.7	0.0	0.0	0.0	0.0	0.0	0.0		3.4	3.4
Electronic Media		0.5	0.5	0.0	0.0	0.0		2.7	2.7		0.6	0.6
Batteries		0.0	0.0		0.0	0.0		0.0	0.0			
Alkaline		0.5	0.5	0.0	0.0	0.0		0.0	0.0		0.1	0.1
Non-alkaline household batteries		0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0

Car batteries		0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0		0.0	0.0
Mercury devices		0.0	0.0	0.0	0.2	0.2		0.0	0.0		0.0	0.0
Motor oil (1)		0.1	0.1	0.0	3.7	3.7		0.0	0.0		0.0	0.0
Other HHW (1)		2.0	2.0	0.0	1.1	1.1		1.2	1.2		0.4	0.4
Small Appliances		18.4	18.4		0.0	0.0		1.2	1.2		7.4	7.4
Tires		0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0
Scrap metal		12.1	12.1	0.0	9.4	9.4		6.9	6.9		5.0	5.0
Subtotal, drop-off recyclables:	**2.3**	**96.2**	**98.5**	**3.0**	**58.5**	**61.5**	**6.7**	**62.9**	**68.7**	**30.7**	**44.9**	**75.6**
Yard Waste	2.9	9.6	12.5	0.0	32.1	32.1	NA			NA		
Residue in yard waste	4.1			0.0								
All Other Waste	0	1,014	**1,014**	0	1,011	**1,011**	0	1,239	1,239	0	339	339

TABLE 3

Summary of Sorting Results and Comparison to Annual Weigh Data

			Sample Weights		Measurements					Annualized Pounds Per Household Set-out (3)		Average Pounds Per Household Per Year from Route Day Data (4)	
	Sample size	out	Refuse (1)	(2)	*Rate*	*Rate*	***Rate***	*Rate*	*Waste Recovery*	Recycling	Refuse	Recycling	Refuse
Route Day	(households)	(households)	(lbs)	(lbs)	(%)	(%)	**(%)**	(%)	(%)	(lbs)	(lbs)	(lbs)	(lbs)
Tuesday	54	46	1860	1419.7	85%	43%	**74%**	3%	NA	1,367	1,791	510	1,281
Wednesday	135	NA	1480	829.9	NA	36%	**64%**	2%	NA	320	570	384	899
Thursday	66	28	2,000	392	42%	16%	**38%**	3%	24%	273	1,576	316	1,570
Friday	56	26	1,540	483	46%	24%	**69%**	5%	80%	449	1,430	313	1,372
											Citywide Average:	*384*	*1,216*

(1) Weights from KTI truck scales.

(2) Weights from DSM scales exclusive of leaf and yard waste and net of contamination.

(3) Annualized data is generated by dividing the sample weights by the number of household units from which the sample was collected and then multiplying the per household unit weights by 52 (weeks).

(4) Data provided by Cambridge for total tons per route day divided by households served per route day.